A FOG AND SMOKE RISK INDEX FOR ESTIMATING ROADWAY VISIBILITY HAZARD

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Abstract

National Weather Service (NWS) observations were compared to Florida Highway Patrol accident site visibility reports to produce a Low Visibility Occurrence Risk Index (LVORI). When LVORI is compared with NWS visibility observations, significant differences are found. These differences appear to be related to two types of fog: advection and radiation. The data suggest that localized radiation fogs pose greater hazards than widespread advection fogs. Apparently, drivers are able to adjust when fog is widespread, but are less successful when very low visibility is suddenly encountered.

1. Introduction

Fog and smoke reduce visibility, and low visibility often results in potentially hazardous driving conditions. On our nation's highways, fog and smoke may cause or significantly contribute to multi-vehicle accidents where lives and property may be lost. For example, on 17 December 1984, one person was killed and two were injured in multiple accidents between 2130 and 2155 LST on Georgia Highway 96 in Twiggs County. According to the newspaper account (Warner Robins *Sun* 1984), a forest burn had caused smoke to accumulate on 5 mi of the highway and in the fatal accident a car ran into a truck that had halted for an earlier accident. National Weather Service reports from Macon, Georgia (about 15 mi WNW of the accident sites) indicated light winds and high humidity (3 knots and 90% at 2200 LST). In fact, average scaler windspeeds for the 17th and 18th of December 1984 were exceptionally low (2.3 and 2.5 mph).

Smoke from forest or agricultural burning is a prolific source of cloud condensation nuclei (Eagan et al. 1974). This smoke has the potential for inadvertent weather modification (Radke et al. 1978; Rogers et al. 1991) including severe reductions in visibility, especially under adverse weather regimes (Paterson 1973; Ward et al. 1979). Prescribed fire, an important land management tool in the southeastern United States, may contribute to roadway visibility hazards. To reduce the risk of these hazards, land managers use public weather forecasts as a prime source of weather information for many prescribed burning operations.

To manage smoke, land managers prefer 12- to 24-h forecasts of weather parameters critical to burning operations. Unfortunately, forecasting low visibility events on this time scale is less accurate than forecasting other critical parameters, such as wind speed and relative humidity. Lavdas (1974) found that necessary criteria (relative humidity at least 95%, surface pressure gradient of 4 mb/5° lat. or less, and a synoptic pattern meeting one of 11 established "types" peculiar to the region) for visibility under 1 mile could be established in coastal Georgia with roughly 90% accuracy. Nearly all low visibility occurrences were associated with the three criteria being met. However, as sufficiency criteria, these stipulations were only about 50% accurate. Low visibility occurred on only about half the occasions that all criteria were met.

Furthermore, an examination of public weather forecasts from 1985 to 1991 for Macon, Georgia revealed that low visibility situations caused revised forecasts. Low visibility occurred more often than it was forecast, and, except when persistently stagnant conditions existed, forecasting low visibility beyond the first period was rare. This study also revealed that windspeed was routinely forecast through the second period and through those third periods that occurred during daylight hours.

The need for smoke-safety measures coupled with the difficulty of accurately forecasting low visibility events provided the impetus to develop measures of fog-related low visibility occurrence based on a risk-oriented analysis. Because the measures would be applied specifically to mitigating roadway hazards from fog or smoke, traffic accident data in the context of available weather data were examined.

2. Developing a Low Visibility Occurrence Risk Index (LVORI)

a. Accident records and weather data

Florida Highway Patrol roadway accident records from the late 1970s and early 1980s include accident-site weather and visibility data. Complete records from 1979 to 1981 were supplied to the USDA Forest Service for analysis. Fog and/or smoke was the primary cause of only 28 of more than 400,000 accidents—a tiny proportion overall and too small a number for reliable statistical analysis. However, over 3,000 accident reports mentioned the presence of fog and/or smoke, a large enough number to yield robust statistics when proportionality testing techniques are applied.

Because the accident reports were made by law enforcement officials not trained as weather observers, the reports may contain some bias. For example, some officials might report a visual obstruction under conditions that would be discounted by others. However, because a large number of reports were analyzed, individual differences have averaged out, resulting in a substantially unbiased data set.

Accident reports were checked for time consistency and those that had recorded the time of accident discovery rather than the time of accident occurrence were discarded. National Weather Service surface and upper air observations surrounding the accident site were used to estimate the weather for the county where the accident occurred. Weather data for the closest available hour were used to construct the estimate.

Weighting factors for surface and upper air observing locations were assigned to each Florida county by using the Barnes (1964) interpolation procedure to establish preliminary factors. These were subjectively adjusted to achieve the geographic balance (north vs. south, east vs. west, land/sea influence) appropriate for each county.

Accident reports mentioning fog and/or smoke were statistically compared to a number of weather parameters, including windspeed, cloud cover, moisture, and dispersion. The most significant relationships were found for relative humidity (RH) and a derived meteorological parameter, the Dispersion Index (DI) (Lavdas 1986).

b. *Dispersion Index (DI)*

Dispersion Index is a measure of the atmosphere's ability to ventilate smoke from areas of prescribed burning activity. The DI may be characterized as the inverse of predicted ground level smoke concentration as estimated by Gaussian plume modeling assuming dispersion coefficients for open country according to Pasquill (1974). The concentration is estimated for a location immediately downwind of a hypothetical 50- by 50-km area source of smoke. This source has a vertical distribution that simulates low intensity prescribed fires (SFFL 1976; Lavdas 1978). Dispersion Index is expressed as a positive number: the higher the DI, the more effective the atmospheric dispersion. A doubling of DI implies a doubling of effective dispersion. An interpretation of DI values is presented in Table 1.

c. *LVORI risk categories*

For statistical analysis, the numbers of fog and/or smoke "mentions" in the Florida Highway Patrol accident reports, the total number of accidents, and the proportionate frequency of fog and/or smoke mentions were tabulated with respect to RH and DI. Examples of the most fog and smoke prone conditions (for RH > 97% and DI < 7) are shown in Table 2. The proportion of fog and/or smoke mentions with respect to the full range of RH and DI is presented in Fig. 1. The figure clearly shows a tendency for the proportions to increase with increasing RH and to decrease with increasing DI. The proportions reach a peak, about 0.15, when RH > 97% and DI = 1 or 2. For RH values < 70% and DI values > 40, the proportions are about 0.001, or about 1/150 of peak proportion. The overall average proportion for all RH and DI values is about 0.0075 or about 1/20 of the peak. Overall response of proportion is fairly uniform with minor statistical irregularities. Proportions of fog and/or smoke mentions are definitely higher for DI values ≤ 12 than for higher DIs and increase as DI decreases further. Similarly, proportions are definitely higher as RH increases to the 75–79% range, and continue to increase as RH continues to increase.

Proportionality tests were conducted on the full data set to create statistically distinct categories. The statistical procedure used (Walpole 1974) consists of confidence interval testing for the difference of two binomial parameters P_1 and P_2. The equation is

$$(p_1 - p_2) - Z\sqrt{\frac{p_1 * q_1}{n_1} + \frac{p_2 * q_2}{n_2}} < P_1 - P_2 < (p_1 - p_2) + Z\sqrt{\frac{p_1 * q_1}{n_1} + \frac{p_2 * q_2}{n_2}}$$

where p_1 and p_2 are proportion of successes (proportion of fog and/or smoke mentions by RH and DI categories) in random samples of size n_1 and n_2 (the total number of accidents by RH and DI categories); $q_1 = 1 - p_1$; $q_2 = 1 - p_2$; n_1 and n_2 must be ≥ 30; and Z denotes the standard normal curve value for the statistical confidence interval desired. For example, Z = 1.96 would be used for 5% confidence testing, because 5.0% of the area of the standard normal curve lies beyond ± 1.96 standard deviations of the mean.

Table 2 shows the proportion for DI = 1 and RH > 97% is slightly less than for DI = 2 and RH > 97%. Testing reveals that this difference is insignificant: If p_1 is the proportion for DI = 1 and p_2 is the proportion for DI = 2, then p_1 = (254/1760) or about 0.1443; p_2 = (231/1563) or about 0.1478; n_1 = 1,760; n_2 = 1,563; the quantity under the square root sign is about 0.0001507; and the confidence interval is (0.1443–0.1478) or 0.0035 ± 0.02406 for a 5% confidence test. Since the confidence interval includes zero, the hypotheses of significant difference between the two proportions is rejected. Accordingly, the highest risk class, LVORI = 10, includes both DI = 1 and DI = 2 when RH > 97%.

A second example illustrates acceptance of a significant difference hypothesis and is used to limit the RH and DI range of the highest risk LVORI class. The next two highest proportions occur for DI = 3 or 4 and DI = 5 or 6 when RH > 97%. When grouped together and compared to DI = 1 or 2 when RH > 97%, p_1 becomes 0.1460; p_2 becomes 0.1071; n_1 is

Table 1. Dispersion Index Interpretation (Lavdas 1986)

DI value	Interpretation	Conditions
> 100	Very Good	May indirectly indicate hazardous burning conditions; check fire weather
61–100	Good	"Good burning weather" conditions are typically in this range
41–60	Fair to Good	Climatological afternoon values in most inland forested areas of the U.S. are in this range
21–40	Fair	Stagnation may be indicated if accompanied by persistent low windspeeds
13–20	Poor to Fair	Stagnation if persistent, but better than average for a night value
7–12	Poor	Stagnant at day, but near or average at night
1–6	Very Poor	Very frequent at night, occurs on a majority of nights in many locations

Table 2. Proportion of Fog and/or Smoke Mentions in Accident Reports by Relative Humidity and Dispersion Index (Selected Cases—see Figure 1 for Full Range)

Relative Humidity	Dispersion Index	Number of Accidents w/ F or K	Total Accidents	Proportion Accidents
> 97%	1	254	1760	.1443
> 97%	2	231	1563	.1478
> 97%	3 or 4	187	1842	.1015
> 97%	5 or 6	176	1548	.1137

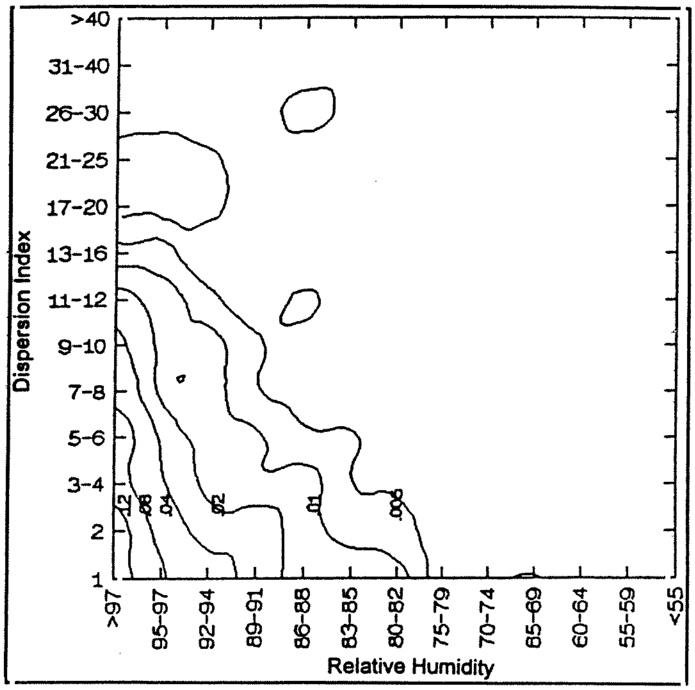

Fig. 1. Frequency of smoke/fog accidents vs. relative humidity and dispersion index.

3,323; n_2 is 3,390; the quantity under the square root sign is 0.00006572; and the confidence interval is (0.1460 − 0.1071) or 0.0389 ± 0.01589. This confidence interval does not include zero, therefore confidence that the difference between the proportions is real is at least 95%.

Many such tests and "countertests" were used to develop 10 distinct categories of risk for LVORI. The confidence tests are dependent on the total number of accidents as shown in Table 2, which defines n_1 and n_2. Keeping the categories as contiguously shaped as practical and eliminating scatter by careful choices in grouping categories of RH and DI was a priority. Marginal cases were decided by the behavior of RH and DI totals because they provided larger and more reliable values of n_1 and n_2 from which to draw statistical inferences. The resultant groupings yielded the Low Visibility Occurrence Risk Index, which is presented as a function of RH and DI in Table 3.

d. Interpretation of LVORI values

The top half of Table 3 presents LVORI values as a function of relative humidity and Dispersion Index. The bottom half of Table 3 gives an interpretation of the 10 categories of LVORI, with risk ranging from lowest (LVORI = 1) to highest (LVORI = 10) class. As the table shows, risk picks up gradually and smoothly as DI goes down and RH goes up; the highest risk

Table 3. LOW VISIBILITY OCCURRENCE RISK INDEX as a function of relative humidity and Dispersion Index (Based on the proportion of accidents with fog and/or smoke, as reported by the Florida Highway Patrol, 1979–1981), after Lavdas and Hauck (1991)

	DISPERSION INDEX											
	1- 1	2- 2	3- 4	5- 6	7- 8	9- 10	11- 12	13- 16	17- 25	26- 30	31- 40	> 40
R.H.												
<55	2	2	2	2	2	2	2	2	2	2	1	1
55–59	3	3	3	3	3	2	2	2	2	2	1	1
60–64	3	3	3	3	3	3	2	2	2	2	1	1
65–69	4	3	3	3	3	3	3	3	3	3	3	1
70–74	4	3	3	3	3	3	3	3	3	3	3	3
75–79	4	4	4	4	4	4	4	4	3	3	3	3
80–82	6	5	5	4	4	4	4	4	3	3	3	3
83–85	6	5	5	5	4	4	4	4	4	4	4	4
86–88	6	6	6	5	5	5	5	4	4	4	4	4
89–91	7	7	6	6	5	5	5	5	4	4	4	4
92–94	8	7	6	6	6	6	5	5	5	4	4	4
95–97	9	8	8	7	6	6	6	5	5	4	4	4
>97	10	10	9	9	8	8	7	5	5	4	4	4

Key to 10 point scale of proportions of smoke and/or fog accidents:

1—Lowest proportion of accidents with smoke and/or fog reported (130 of 127,604 accidents, or just over 0.0010 accidents)
2—Physical or statistical reasons for not including in category 1, but proportion of accidents not significantly higher
3—Higher proportion of accidents than category 1, by about 30 to 50 per cent, marginal significance (between 1 and 5 per cent)
4—Significantly higher than category 1, by about a factor of 2
5—Significantly higher than category 1, by a factor of 3 to 10
6—Significantly higher than category 1, by a factor of 10 to 20
7—Significantly higher than category 1, by a factor of 20 to 40
8—Significantly higher than category 1, by a factor of 40 to 75
9—Significantly higher than category 1, by a factor of 75 to 125
10—Significantly higher than category 1, by about a factor of 150

Note: The overall number of accidents with fog and/or smoke reported is 3,235 out of a total of 433,649 accident reports analyzed. Of these, 604 included smoke, 2,972 included fog, and 341 included both.

is associated with a combination of low DI values and high RH values. The greatest jump with increased RH is two LVORI classes; with decreased DI, the greatest jump is also two LVORI classes. When an increase in RH and a decrease in DI are combined, the greatest jump is three classes (from LVORI = 6 for RH = 97% and DI = 7, to LVORI = 9 for RH = 98% and DI = 6).

Table 3 indicates that the risk of smoke and fog reports at an accident site increases when RH ≥ 80%, especially for very low DI values. Risk is highest for saturated conditions, (RH > 97% and DI = 1 or 2), however, risk remains high for saturated RH with DI values up to 12.

An important distinction between DI and LVORI exists. Dispersion Index represents a physical quantity and is a real, positive number with no upper bound. On the other hand, LVORI is an indicator only of relative risk, and should not be used as a hard estimate of absolute risk of hazardous visibility.

e. LVORI seasonal and diurnal variations

During fair weather, daytime warming influences three factors that increase DI. Surface-based warming produces a more unstable mixing layer. The warming also produces a deeper mixing layer, and a deeper mixing layer usually has a greater transport windspeed. At night, a surface inversion (stable conditions), with no thermally defined mixing height and low surface windspeeds results in low DI values. The DI tends to track with temperature during the course of a day, while RH tends to track inversely with temperature. Therefore, LVORI, which increases with decreasing DI and with increasing RH, has an inverse relationship to the diurnal temperature curve. On a fair day, low values of LVORI are usual in early afternoon with high values the following night and early morning (Lavdas and Hauck 1991). Figures 2 and 3 show annual and diurnal frequencies of favorable LVORI values (LVORI ≤ 3) and unfavorable values (LVORI ≥ 7) observed in Florida from 1979 to 1981.

In Fig. 2, LVORI values ≤ 3 are commonplace in the afternoon (18 and 21Z) when frequencies range from about 0.85 in December to about 0.95 in June. The effect of the annual cycle of day length is apparent in the 15Z and 00Z curves, while minimum frequencies are observed in late night and early morning, between 06 and 12Z. Values of LVORI ≤ 3 are rare between 03Z and 12Z, especially in late summer. In Fig. 3, the frequency of LVORI values ≥ 7 is highest late at night (usually 09Z, but sometimes 12Z in the winter) with the peak nighttime frequencies occurring in August. Daytime frequencies are generally less than 0.05 with the lowest frequencies occurring in spring and early summer.

The LVORI is another climatological tool that land managers can use to evaluate smoke-related visibility hazards. The prescribed burner can use LVORI to determine the degree of relative risk in conducting a prescribed fire, and, given the climatology of the area, how much risk is justified. For example, since (Fig. 3) the maximum frequency of LVORI ≥ 7 is about 0.50, a fire manager may decide that a LVORI of 8 constitutes unjustified risk for unattended, smoldering smoke sources after a burn. Also, since LVORI ≤ 3 is uniformly attainable during day according to Fig. 2, a decision to require such values during active burning would have a relatively minimal effect on burning operations.

Finally, LVORI frequencies are highly variable with respect to location. Low Visibility Occurrence Risk Index frequencies in other states will vary considerably from those in Florida. Within Florida, northern and inland locations experience many more observations of LVORI ≥ 7 than coastal and southern locations. Figure 4 shows a maximum frequency at Tallahassee and a minimum frequency at Key West. Considerable variation from Figs. 2 and 3 would result if figures for individual stations within the state were plotted.

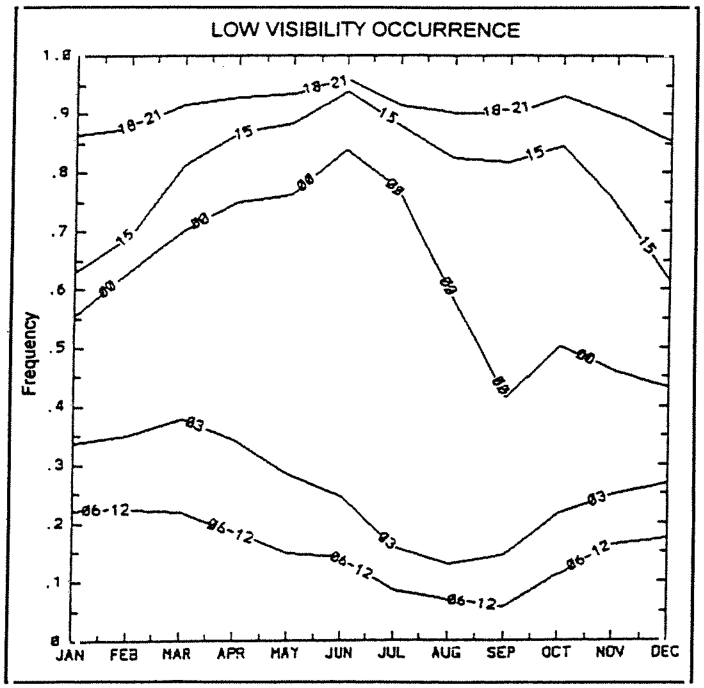

Fig. 2. Frequency of low risk LVORI (≤3) by month and by hour (UTC).

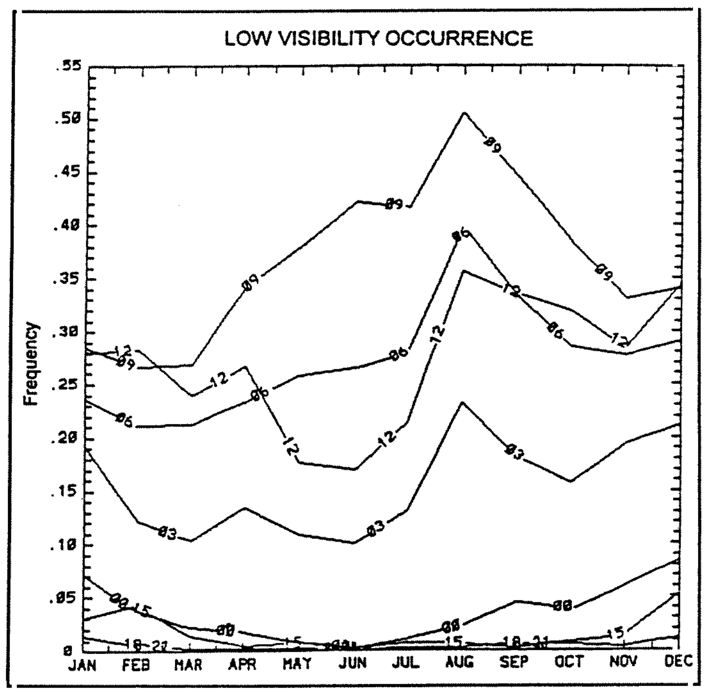

Fig. 3. Frequency of high risk LVORI (≥7) by month and by hour (UTC).

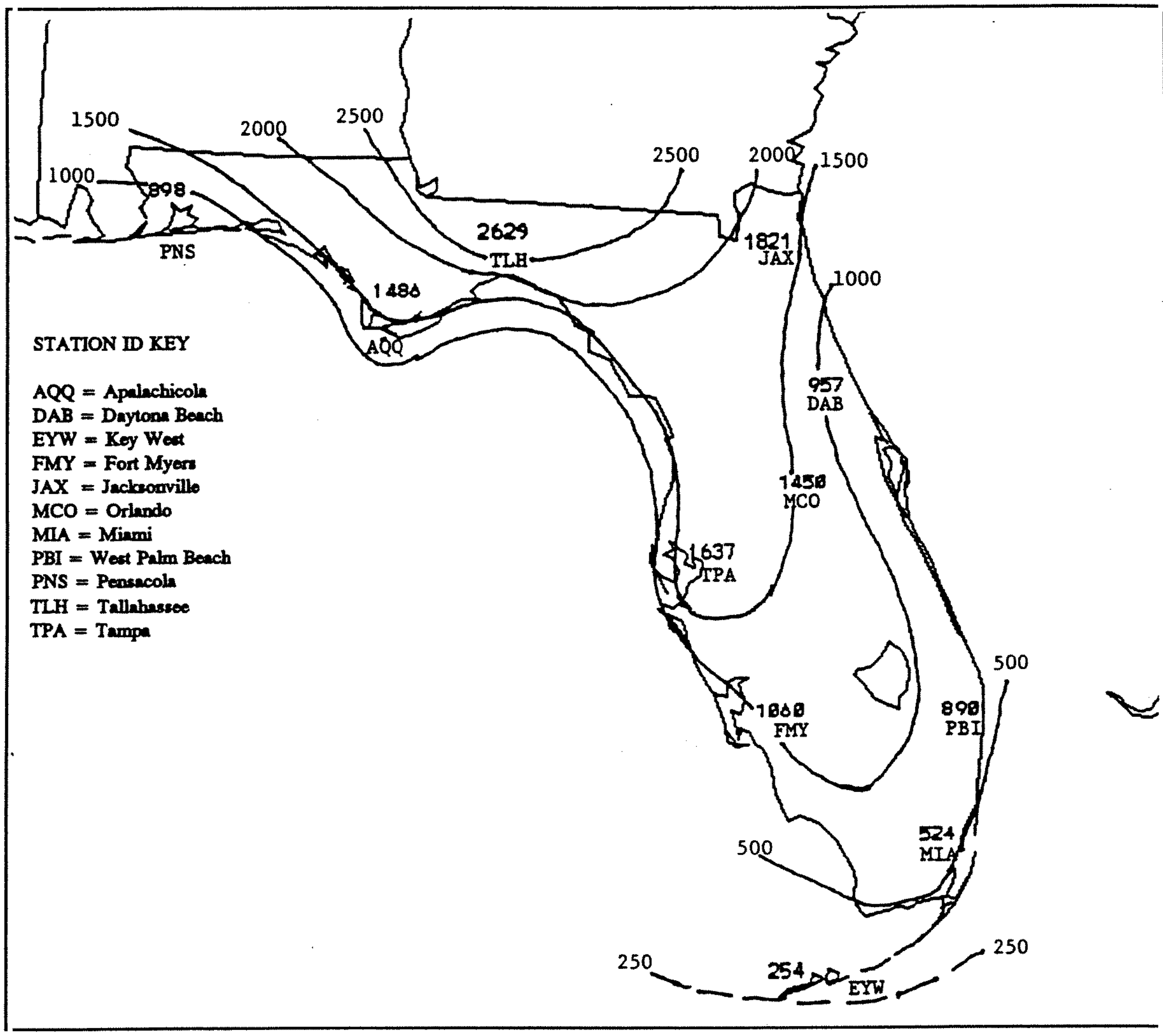

Fig. 4. Number of observations (out of 8,768) with LVORI ≥ 7.

3. Comparing LVORI with National Weather Service Observations of Low Visibility

Table 4 directly compares LVORI and frequency of NWS low visibility reports (≤ 1 mi and ≤ 1/4 mi) at National Weather Service stations in Florida during the 1979–1981 period. The frequency of NWS low visibility reports increases with increasing LVORI class, being at or near zero for LVORI ≤ 3, but increasing to just over 9% (≤ 1/4 mi) and over 16% (≤ 1 mi) for LVORI = 10. Low visibility in Florida is a rather rare event. Only 619 of 96,522 (3 hourly) observations reported visibility ≤ 1/4 mi, while 1,529 (3 hourly) observations gave a visibility ≤ 1 mi. With 11 stations reporting over a 3-year period, annual observations of visibility ≤ 1/4 mi averaged 19 while those ≤ 1 mi averaged 46.

Low visibilities are most common in the northern part of the state—the three panhandle stations (PNS, AQQ, and TLH) as well as JAX averaged about 100 occurrences of visibility ≤ 1/4 mi (of 8,776 possible) over the 3-year period. In the central part of the state (DAB, MCO and TPA), about 50 such occurrences were reported; FMY in the southwestern peninsula reported approximately 25 occurrences. The three stations closest to the Gulf Stream (PBI, MIA, and EYW) rarely reported low visibility, with 10 observations at most in the 3-year period. Visibility ≤ 1 mi is 2 to 3 times more frequent than visibility ≤ 1/4 mi, but the geographic pattern of 1 mi occurrences is similar to the 1/4 mi occurrences within the state. The distribution of low visibility in Florida is important when evaluating LVORI and low visibility frequencies because wide geographic variations are encountered within the state. A mental picture of these variations may be gleaned from Fig. 4. Low visibility frequencies at some locations can differ greatly from the statewide values which are given in Table 4.

4. Explaining the Disparity between NWS and LVORI Observations

a. Nature of the disparity

Figure 5 shows how NWS observations of low visibility vary with relative humidity and Dispersion Index. There is the expected increase of relative frequencies of low visibility with relative humidity. However, the weak relationship with DI was unexpected (compare with Fig. 1). To help explain the underlying causes for the disparity, Fig. 6 was constructed to show how NWS low visibility observations and LVORI low visibility

Table 4. Frequency of low visibility reports (1/4 mile or less and 1 mile or less) vs. LVORI for National Weather Service stations in Florida 1979–1981

LVORI	# Low Vis. (1/4 mile)	# Low Vis. (1 mile)	# Total Obs. w/ Vis.	Frequency (1/4 mile)	Frequency (1 mile)
1	3	7	18008	.0002	.0004
2	0	3	7318	.0000	.0004
3	0	13	21932	.0000	.0006
4	9	89	14209	.0006	.0063
5	34	200	10385	.0033	.0193
6	76	212	11034	.0069	.0192
7	53	151	4997	.0106	.0302
8	115	263	4310	.0267	.0610
9	184	330	2726	.0675	.1211
10	145	261	1603	.0905	.1628
Total	619	1529	96522	.0064	.0158

observations for all relative humidities vary with DI. For ease of interpretation, both sets of relative frequencies were normalized by their respective values at DI = 1. The results confirm two conclusions regarding Figs. 1 and 5: (1) The relative frequencies of low visibilities caused by fog and/or smoke as observed at NWS sites in Florida are mostly independent of DI for DI < 12, and (2) low visibilities observed at accident sites decline for increasing DI.

b. Meteorological explanation

To find the underlying meteorological reasons for the differences between Figs. 1 and 5, the NWS low visibility reports were stratified by wind speed. These results, ordered by DI, are shown in Table 5. The most significant finding for this study is the decline in the number of observations for each DI category. For DI = 5–6, the number of observations drops from 9,645 to 1,417 when wind speed < 5 kts, and to 83 for near calm conditions. The number of observations for DI = 1 remains essentially unchanged. These results lead to the conclusion that DI is strongly dependent on wind speed when DI < 20.

If DI were replaced by wind speed in Fig. 6, the NWS and LVORI curves would remain essentially unchanged. The NWS visibility reports remain relatively independent of wind speed for DI < 12, while the visibility reports associated with LVORI are critically dependent upon very light wind speeds (DI < 3).

The meteorological explanation for the difference between the NWS visibility observations and LVORI is based on the two common types of fog: advection fog and radiation fog. Figure 7, a schematic showing the relative frequencies of fog and smoke as a function of wind speed, depicts the fact that advection fogs are much less dependent on wind speed than radiation fogs. Radiation fog occurs only under near-calm conditions. Indeed there exists a wind speed threshold above which radiation fog will not form. Therefore, the authors conclude that fogs reported in the Florida Highway Patrol accident site reports associated with the formulation of LVORI are predominantly radiation fog events.

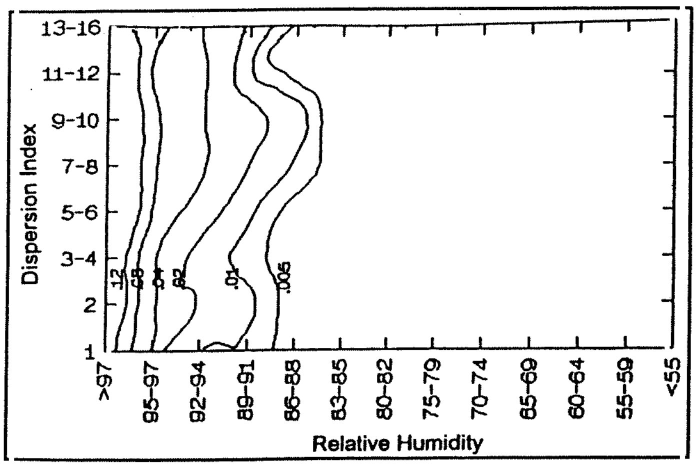

Fig. 5. Frequency of low visibility reports vs. relative humidity and dispersion index.

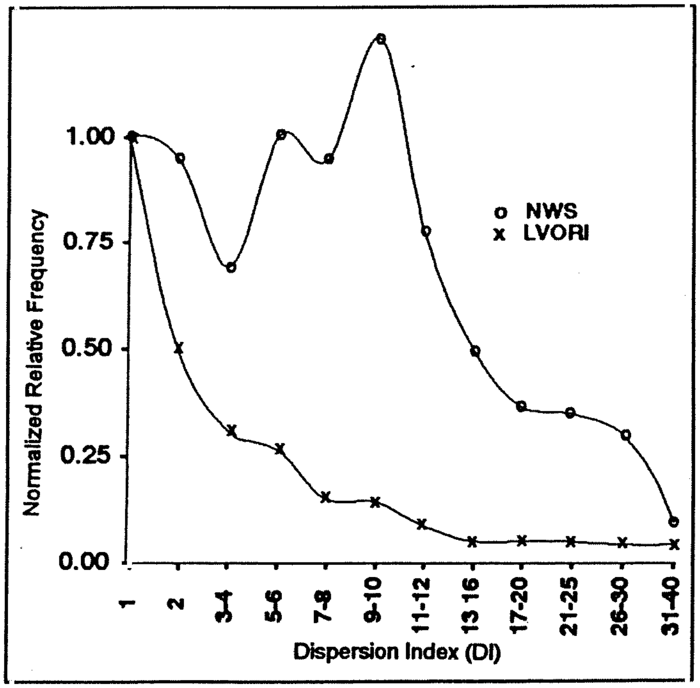

Fig. 6. Normalized relative frequencies of NWS observations of low visibility and LVORI.

Table 5. Low Visibility (1 mile or less) vs. Dispersion Index, Stratified by Windspeed and Compared to the LVORI Data Base

	WIND SPEED CATEGORY (knots)			
Dispersion Index	All	<5	Calm	LVORI
1	219	218	214	806
1	8171	8168	7979	17077
1	.0268	.0267	.0268	.0472
2	225	225	135	710
2	8895	8895	1135	24136
2	.0253	.0253	.1189	.0294
3–4	218	179	21	579
3–4	12008	3424	286	38751
3–4	.0182	.0523	.0734	.0149
5–6	260	86	8	408
5–6	9645	1417	83	32287
5–6	.0270	.0607	.0964	.0126
7–8	157	18	1	183
7–8	6215	333	59	23893
7–8	.0253	.0541	.0169	.0077
9–10	133	10	0	121
9–10	3927	215	50	17029
9–10	.0339	.0465	.0000	.0071
11–12	74	4	0	60
11–12	3578	202	50	14351
11–12	.0207	.0198	.0000	.0042
13–16	87	5	1	53
13–16	6601	452	80	24608
13–16	.0132	.0111	.0125	.0022
17–20	40	4	1	32
17–20	4098	457	53	18458
17–20	.0098	.0088	.0189	.0017
21–25	37	1	0	35
21–25	3990	478	56	20960
21–25	.0093	.0021	.0000	.0017
26–30	30	2	1	38
26–30	3755	330	37	22612
26–30	.0080	.0061	.0270	.0017
31–40	24	0	0	76
31–40	8717	403	34	58394
31–40	.0028	.0000	.0000	.0013
>40	28	0	0	134
>40	16928	339	20	121093
>40	.0017	.0000	.0000	.0011
Total	1532	752	382	3235
Total	96528	25113	9922	433649
Total	.0159	.0299	.0385	.0075

Table Key: Row 1 of each Dispersion Index—# Low Vis. Cases; Row 2 of each Dispersion Index—# Observations; Row 3 of each Dispersion Index—Frequency Low Vis.

c. Driver response explanation

Accident site fogs are primarily radiation fogs because drivers may respond differently to the two types of fog: radiation fog and advection fog. Drivers in advection fog adjust speed according to visibility and proceed with confidence that conditions down the road will remain unchanged. Radiation fog, a more local phenomenon, tends to occur around open fields or stream cuts in shallow depressions. Visibilities can change suddenly from near perfect to near zero. Driver responses can range from "continuing on blindly" to "slamming on the brakes" and often result in accidents, many of which are multiple car pileups.

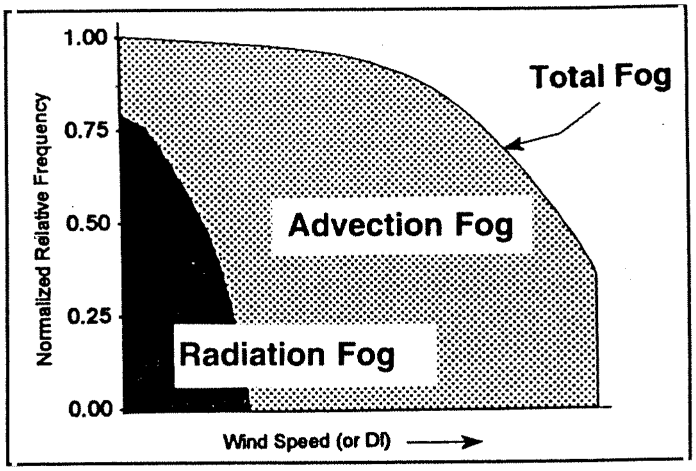

Fig. 7. Schematic showing relative frequencies of advection fog and radiation fog as parts of total number of NWS fog observations in Florida 1979–1981.

5. Concluding Remarks

Developing a weather index, LVORI, that identifies levels of visibility hazard and specifically addresses the risk of those fogs most associated with automobile accidents is a major accomplishment of this study. Further verification of LVORI with independent data will broaden geographic and public safety applications for this new index. The index could be used to help define a threshold for smoke and fog as an accident factor. With that threshold, more effective devices might be developed to warn of low visibility obstruction on highways, especially in the most smoke and fog prone areas.

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